

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

AB-1101 US

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/743536

INTERNATIONAL APPLICATION NO.  
PCT/JP99/03714INTERNATIONAL FILING DATE  
09 July 1999PRIORITY DATE CLAIMED  
10 July 1998TITLE OF INVENTION  
ELECTROCONDUCTIVE CONTACT UNIT ASSEMBLYAPPLICANT(S) FOR DO/EO/US  
TOSHIO KAZAMA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).
4. ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
  - b. ☒ has been communicated by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
  - b. ☒ have been communicated by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

## Items 11 to 16 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.  
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:

Form PTO-1449

Cited References (6)

APPLICATION NO (if known, see 37 CFR 1.5)

INTERNATIONAL APPLICATION NO  
 PCT/JP99/03714

097743536

CALCULATIONS PTO USE ONLY

17. ☒ The following fees are submitted:

**BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)):**

Neither international preliminary examination fee (37 CFR 1.482)  
 nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO  
 and International Search Report not prepared by the EPO or JPO ..... \$1000.00

International preliminary examination fee (37 CFR 1.482) not paid to  
 USPTO but International Search Report prepared by the EPO or JPO ..... \$860.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but  
 international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$710.00

International preliminary examination fee paid to USPTO (37 CFR 1.482)  
 but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... \$690.00

International preliminary examination fee paid to USPTO (37 CFR 1.482)  
 and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$100.00

**ENTER APPROPRIATE BASIC FEE AMOUNT =**

\$ 860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30  
 months from the earliest claimed priority date (37 CFR 1.492(e)).

\$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	15 - 20 =		X \$18.00
Independent claims	1 - 3 =		X \$80.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00

\$ 0.00

\$ 0.00

\$

**TOTAL OF ABOVE CALCULATIONS =**

\$ 860.00

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above  
 are reduced by 1/2.

\$

**SUBTOTAL =**

\$ 860.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30  
 months from the earliest claimed priority date (37 CFR 1.492(f)).

\$

**TOTAL NATIONAL FEE =**

\$ 860.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be  
 accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property

\$

**TOTAL FEES ENCLOSED =**

\$ 860.00

Amount to be  
 refunded:

\$

charged:

\$ 860.00

a. ☐ A check in the amount of \$\_\_\_\_\_ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 19-2386 in the amount of \$ 860.00 to cover the above fees.  
 A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any  
 overpayment to Deposit Account No. 19-2386. A duplicate copy of this sheet is enclosed.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR  
 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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REGISTRATION NUMBER

**EXPRESS MAIL LABEL NO. EL710208525US**

09/743530

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: KAZAMA, Toshio JG07 RECEIVED 10 JAN 2001  
Assignee: NHK Spring Co., Ltd.  
Title: ELECTROCONDUCTIVE CONTACT UNIT ASSEMBLY  
Serial No.: Unknown Filing Date: Herewith  
Examiner: Unknown Group Art Unit: Unknown  
Docket No.: AB-1101 US

San Jose, California  
January 10, 2001

BOX PCT  
COMMISSIONER FOR PATENTS  
Washington, D. C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

Please cancel Claims 1 through 7 and add the following new claims:

--8. An electroconductive contact unit assembly comprising an electroconductive contact unit in the form of a coil spring for resiliently contacting an object to be contacted, the contact unit being coaxially received in a through hole formed in an insulating support member, characterized by that:

the through hole is shaped so as to have a reduced diameter portion at least at one axial end thereof;

the contact unit in the form of a coil spring comprising a coil spring portion received in an intermediate part of the through hole and at least one electrode pin portion which is closely wound at one end of the coil spring portion and tapered or stepped in shape so as to be prevented from coming off by the reduced diameter portion;

only the closely wound portion of the contact unit being surface processed so as to form a layer of electroconductive material over an outer circumferential surface thereof in a continuous manner.

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9. An electroconductive contact unit assembly according to Claim 8, wherein the reduced diameter portion comprises a tapered hole section provided at each axial end of the through hole, and the electrode pin portion is formed at each end of the coil spring portion, and is tapered in shape and closely wound so as to be prevented from coming off by the corresponding tapered hole section of the through hole.

10. An electroconductive contact unit assembly according to Claim 8, wherein the reduced diameter portion has a smaller inner diameter than the outer diameter of the coil spring portion, and is provided at each axial end of the through hole.

11. An electroconductive contact unit assembly according to Claim 8, wherein the coil spring portion is wound at a uniform pitch.

12. An electroconductive contact unit assembly according to Claim 8, wherein the electrode pin portions are each closely wound with a pre-stress.

13. An electroconductive contact unit assembly according to Claim 11, wherein the electrode pin portions are each closely wound with a pre-stress.

14. An electroconductive contact unit according to Claim 8, wherein the surface processing is conducted after the coil spring portion and electrode pin portions are formed out of a wire member.

15. An electroconductive contact unit according to Claim 11, wherein the surface processing is conducted after the coil spring portion and electrode pin portions are formed out of a wire member.

16. An electroconductive contact unit according to Claim 12, wherein the surface processing is conducted after the coil spring portion and electrode pin portions are formed out of a wire member.

17. An electroconductive contact unit according to Claim 13, wherein the surface processing is conducted after the coil spring portion and electrode pin portions are formed out of a wire member.

18. An electroconductive contact unit according to Claim 14, wherein the surface processing is conducted after the coil spring portion and electrode pin portions are formed out of a wire member.

19. An electroconductive contact unit according to Claim 8, wherein the surface processing is conducted both before and after the coil spring portion and electrode pin portions are formed out of a wire member.

20. An electroconductive contact unit according to Claim 11, wherein the surface processing is conducted both before and after the coil spring portion and electrode pin portion are formed out of a wire member.

21. An electroconductive contact unit according to Claim 12, wherein the surface processing is conducted both before and after the coil spring portion and electrode pin portions are formed out of a wire member.

22. An electroconductive contact unit according to Claim 13, wherein the surface processing is conducted both before and after the coil spring portion and electrode pin portions are formed out of a wire member.--

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REMARKS

Applicant's attorney respectfully requests entry of this Preliminary Amendment.  
Should the Examiner have any questions, the Examiner is invited to telephone the undersigned at 408 453-9200.

EXPRESS MAIL LABEL NO:

EL710208525US

Respectfully submitted,  
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## DESCRIPTION

## ELECTROCONDUCTIVE CONTACT UNIT ASSEMBLY

TECHNICAL FIELD

The present invention relates to an electroconductive contact unit  
5 assembly which is suitable for use in contact probes and probe cards for  
testing semiconductor devices and wafers, sockets in such forms as LGA (land  
grid array), BGA (ball grid array), CDP (chip side package) and bare chip, and  
connectors.

BACKGROUND OF THE INVENTION

10 Conventionally, various forms of electroconductive contact units have  
been used in contact probes for conducting electric tests on electroconductive  
patterns of printed circuit boards and electronic component parts (open/short  
tests, environment tests and burn-in tests), sockets (including packages) for  
semiconductor devices (LGA, BGA, CSP and bare chip), and connectors.

15 When using such a socket for semiconductor devices, it is necessary to  
consider the fact that signal frequencies for semiconductor devices have  
significantly increased in recent years, and may be as high as hundreds of  
MHz. A socket for semiconductor devices that operate at such a high  
frequency level is required to use electroconductive contact units of low  
20 inductance and resistance and to be of a highly compact design in terms of  
mounting space.

BRIEF SUMMARY OF THE INVENTION

To accomplish such a task, and provide an electroconductive contact  
unit assembly having low electric inductance and resistance to meet the need  
25 in high frequency operation, and featuring a highly compact design, the

present invention provides an electroconductive contact unit assembly comprising a electroconductive contact unit in the form of a coil spring for resiliently contacting an object to be contacted, the contact unit being coaxially received in a through hole formed in an insulating support member,

5 characterized by that: the through hole is shaped so as to have a reduced diameter portion at least at one axial end thereof; the contact unit in the form of a coil spring comprising a coil spring portion received in an intermediate part of the through hole and a pair of electrode pin portions, which are each closely wound at corresponding ends of the coil spring portion, and at least

10 one of which is tapered or stepped in shape so as to be prevented from coming off by the reduced diameter portion; the contact unit being surface processed by highly electroconductive material.

Thus, a low electric resistance is accomplished because there are no parts connecting different components as opposed to the arrangement using an

15 electroconductive needle member and an electroconductive coil spring, and a low electric inductance can be accomplished because the coil spring is closely wound and surface processed with highly electroconductive material, thereby providing a straight electric path along the axial direction of the closely wound portion of the coil spring. Because the electrode pin portions are retained and

20 positioned by the cooperation between the tapered sections of the through hole and the tapered electrode pin portions, the axial length can be minimized and the contact unit is made more suited for compact design as opposed to the arrangement which slidably supports a needle member with a straight hole.

Preferably, the reduced diameter portion comprises a tapered hole

25 section provided at each axial end of the through hole, and the pair of



electrode pin portions are tapered in shape and closely wound so as to be prevented from coming off by the tapered hole sections of the through hole. Thus, the retention and positioning of the both electrode pin portions of the electroconductive contact unit having two moveable ends can be accomplished,  
 5 and the aforementioned advantages can be obtained.

According to a preferred embodiment of the present invention, the reduced diameter portion has a smaller inner diameter than the outer diameter of the coil spring portion, and is provided at each axial end of the through hole, and the other of the pair of electrode pin portions has a cylindrical shape  
 10 which has a smaller diameter than the reduced diameter portion. Thus, when the object to be contacted has a convex surface as is the case with a solder ball, the electrode pin portion having a cylindrical shape can be applied to the object to be contacted with a certain guiding action, and a stable contact with an object such as a solder ball can be achieved.

15 If the coil spring portion is wound at a uniform pitch, because the contact unit consists of closely wound portions and a uniform pitch portion, it can be formed with a simple coiling process.

If the electrode pin portions are each closely wound with a pre-stress, the contact between the adjacent turns of the coil wire can be improved.

20 If the surface processing is conducted after the coil spring portion and electrode pin portions are formed out of a wire member, the manufacturing process can be simplified, and the contact resistance of the closely wound portions can be minimized.

If the surface processing is conducted both before and after the coil  
 25 spring portion and electrode pin portions are formed out of a wire member, the

contact resistance of the closely wound portions can be minimized.

### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an enlarged sectional side view of an essential part of a socket for semiconductor devices embodying the present invention;

5        Figure 2(a) is a fragmentary perspective view of an essential part showing the coil wire which is gold plated;

Figure 2(b) is a view similar to Figure 2(a) showing the coil wire after it is closely wound;

10       Figure 2(c) is a view similar to Figure 2(b) showing the coil wire after it is gold plated once again;

Figure 3 is a view similar to Figure 1 showing the socket for semiconductor devices embodying the present invention during in use;

Figure 4 is a view similar to Figure 1 showing a second embodiment of the present invention;

15       Figure 5 is a view similar to Figure 3 showing the second embodiment of the present invention;

Figure 6 is a view showing a third embodiment of the present invention;

20       Figure 7(a) is a fragmentary perspective view of an essential part of a coil wire following a coiling process; and

Figure 7(b) is a similar view following a gold plating process.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now the present invention is described in the following in more detail in terms of concrete embodiments with reference to the appended drawings.

25       Figure 1 is an enlarged sectional side view of an essential part of a

socket for semiconductor devices embodying the present invention. The illustrated socket comprises an insulating support member, for instance, consisting of a pair of insulating plates 1 which are made of plastic material and laminated one over the other. The support member integrally combining  
 5 the two insulating plates 1 is provided with a through hole 2 extending across the thickness of the insulating plates 1, and an electroconductive contact unit 3 in the form of a coil spring is coaxially received in the through hole 2.

The through hole 2 comprises a linear and straight hole section having a uniform diameter and extending over a certain axial length in an axially  
 10 intermediate part, and tapered hole sections 2a connected to either axial end of the intermediate part of the through hole 2 and each having an open outer end. Each tapered hole section 2a opens to the outside via a straight small hole section 2b having a uniform diameter and a prescribed length.

The electroconductive contact unit 3 in the form of a coil spring is  
 15 formed by winding a coil wire made of spring material into a coil, and comprises a coil spring portion 4 received in the linear and straight section of the through hole 2 with a certain radial play, and wound at a prescribed pitch, and a pair of electrode pin portions 5a and 5b each consisting of a closely wound portion including a plurality of turns provided adjacent to the  
 20 corresponding axial end of the coil spring portion 4 and having a same diameter as the coil spring portion 4 and tapered portion extending to the coil end. The tapered portion of each of the electrode pin portions 5a or 5b has a complementary shape with respect to the tapered hole sections 2a of the through hole 2, and the pointed end includes a portion having a smaller  
 25 diameter than the straight small hole section 2b so that the pointed end may

project out of the straight small hole section 2b.

The electroconductive contact unit 3 in the form of a coil spring is received in the through hole 2 with the coil spring portion 4 placed under compression. For instance, the two insulating plates 1 are placed one over the other with the electrode pin portions 5a and 5b received in the corresponding parts of the through hole 2 formed in the insulating plates 1 so that the electroconductive contact unit 3 in the form of a coil spring may be assembled in the insulating plates 1 with the coil spring portion 4 placed under a pre-stress. It is also possible to place the electroconductive contact unit 3 in the through hole 2 without compressing the coil spring portion 4. This simplifies the assembly work.

Because the electrode pin portions 5a and 5b are tapered, simply by slightly fitting their free ends in the openings of the corresponding portions of the through hole 2 of the insulating plates 1, the electrode pin portions 5a and 5b are snugly received in the tapered hole sections 2a as the two insulating plates 1 are placed one over the other owing to the guiding action of the tapered hole sections 2a for the electrode pin portions 5a and 5b. Therefore, as opposed to the prior art which required each needle shaped electrode pin to be fitted into a corresponding hole, the assembly work is substantially simplified.

When the two insulating plates 1 are assembly to each other in close contact by using threaded bolts or the like, the resilient force of the coil spring portion 4 pushes the tapered portions of the electrode pin portions 5a and 5b against the tapered surfaces of the corresponding tapered hole sections 2a which are complementary to the tapered portions of the electrode pin portions 5a and 5b. Owing to the engagement between the opposing tapered surfaces,

the lateral shifting of the free ends of the electrode pin portions 5a and 5b can be favorably minimized. Therefore, when a plurality of such electroconductive contact units are arranged in a matrix as is the case with a socket, the projecting end of each electrode pin portion 5a or 5b can be arranged in a planar coordinate system at a high precision without any effort during the assembly work.

Thus, each electrode pin portion 5a or 5b of the electroconductive contact unit 3 in the form of a coil spring received in the through hole 2 can project out of the through hole 2 by a prescribed length under a rest condition.

When the socket is in use, the electrode pin portions 5a and 5b are brought into contact with the circuit pattern 6a of the printed circuit board 6 and a terminal 7a of a semiconductor device which, for instance, may consist of a solder ball of a BGA 7

By applying a pre-stress to the electroconductive contact unit 3 in the form of a coil spring, the fluctuation in the load owing to the fluctuation in the deflection of each electroconductive contact unit or the fluctuation in the height of the object to be tested (circuit pattern 6a or terminal 7a) can be favorably minimized.

Figure 2 shows the mode of making the electroconductive contact unit 1 in the form of a coil spring according to the present invention. First of all, as shown in Figure 2(a), a coil wire 3a made of spring material as mentioned earlier is plated with gold which is a highly electroconductive material, and a gold plate layer 8a is formed over the entire outer surface of the coil wire 3a. The plating material is not limited to gold, but may also consist of Ni or Cu.

Then, the gold-plated coil wire 3a is subjected to a coiling process,

and formed so as to have the coil spring portion 4 and the electrode pin portions 5a and 5b as illustrated in Figure 1. The electrode pin portions 5a and 5b are each closely wound as illustrated in Figure 2(b), and the adjacent turns of the coil wire 3a in the closely wound portion is made to abut each other by  
 5 applying a pre-stress to the coil wire 3a. As a result, in each of the electrode pin portions 5a and 5b which consist of closely wound portions, the adjacent turns of the coil wire 3a are in contact with each other via the gold plate layer 8a with a certain biasing force acting between them.

Referring to Figure 2(c), an additional gold plating process is applied  
 10 to the assembly in the state illustrated in Figure 2(b), and a second gold plate layer 8b is formed over the entire outer circumferential surface of each closely wound portion. In this case also, the plating material is not limited to gold, but may also consist of Ni or Cu. As a result, the adjacent turns of the coil wire 3a is joined together not only by the mechanical biasing force but also by the  
 15 second gold plate layer 8b which is formed continuously in the axial direction of the coil. This not only ensures a close contact between the adjacent turns of the coil wire 3a but also reduces the electric resistance which otherwise relies strictly on the close contact between the adjacent turns of the coil wire 3a.

Figure 3 shows a socket using a number of electroconductive contact  
 20 units 3 in the form of a coil spring having the above described structure. In this case, because the electric signal is conducted solely through the electroconductive contact unit 3 in the form of a coil spring, and there is no connecting part such as a solder connection between the circuit board 6 and the BGA 7, the electric resistance can be stabilized. The coil spring portion 4  
 25 is necessary for bringing the contact unit into a resilient contact with the object

to be accessed, and the electric inductance  $H$  is related to the number of turns  $N$  of the coil wire 3a by the relationship  $H=AN^2/L$  where  $A$  is a coefficient and  $L$  is the length of the spring. Therefore, it can be seen that  $N$  should be as small as possible to minimize the electric inductance, and the spring portion

5 preferably consists of about two turns, but may consist of up to 10 turns.

Because the adjacent turns of the coil wire in the electrode pin portions 5a and 5b are in close contact with each other under a pre-stress, and the assembly is entirely covered by the second gold plate layer 8b which continuously extends in the axial direction of the coil, the path of electric

10 conduction in each of the electrode pin portions 5a and 5b extends linearly along the axial direction of the coil. Therefore, even though the coil wire is wound into a coil, the electric current does not flow along a spiral path, and this contributes to the reduction in the electric resistance and inductance.

Because the straight small hole section 2b connects the terminal end

15 of the tapered hole section 2a of the through hole 2 to the outside, the free ends of the tapered electrode pin portions 5a and 5b would not be inadvertently caught by the terminal end of the tapered hole section 2a of the through hole 2. Owing to the shape of the straight small hole section 2b, a certain thickness is ensured to the opening, and this prevents inadvertent

20 damage to the opening by contact with the terminal which consists of a solder ball.

Figure 4 shows a second embodiment of the present invention. The parts corresponding to those of the previous embodiment are denoted with like numerals, and are not described again. In this embodiment, a stopper 11

25 similarly made of insulating material is laminated over the upper surface of the

upper insulating plate 1 as seen in the drawing, and a hole 11a is passed through the stopper 11 in registration with the through hole 2.

The lower electrode pin portion 5a in the drawing is tapered in a similar manner as in the previous embodiment, but the upper electrode pin portion 5c consists of a cylindrical portion having a smaller diameter than the coil spring portion 4, and is received in the hole 11a.

The mode of use of this electroconductive contact unit 13 in the form of a coil spring in a socket is illustrated in Figure 5 which is similar to Figure 3. As mentioned earlier, because the stopper 11 is laminated over the upper surface of the insulating plate 1, the lower surface of the BGA 7 engages the upper surface of the stopper 11, thereby determining the position of the BGA 7. Therefore, the distance of intrusion of the terminal 7a into the hole 11a is favorably controlled, and the electrode pin portion 5c can engage the terminal 7a with a constant load at all times. Therefore, the contact pressure of the electroconductive contact unit can be stabilized as compared with the case where the stopper 11 is not used, and a stable state of contact may be maintained when testing a large number of identical products.

In the second embodiment also, because the electric current does not flow along a spiral path in the electrode pin portions 5a and 5c, the electric resistance and inductance can be reduced.

Figure 6 shows a third embodiment of the present invention. The parts corresponding to those of the previous embodiments are denoted with like numerals, and are not described again.

In the third embodiment, there is no tapered hole section 2a which is connected to the intermediate part of the through hole 2. Instead, a retaining



plate 12 is laminated over the lower surface of the lower insulating plate 1 to prevent the lower tapered electrode pin portion 5a from coming off. The retaining plate 12 is formed with a small hole 12b which has a smaller diameter than the coil spring portion 4, and the electroconductive contact unit 3 in the form of a coil spring received in the through hole 2 is prevented from coming off by the axially intermediate part of the tapered electrode pin portion 5a abutting the edge of the small hole 12b.

The electrode pin portion 5b on the upper end of the coil spring portion 4 consists of a closely wound straight portion having a same diameter as the coil spring portion 4. Thus, even when the electroconductive contact unit 3 in the form of a coil spring is not retained in one direction, it can be used in a similar manner as in the other embodiments without any inconvenience by placing the assembly so that the tapered electrode pin portion 5a faces downward as shown in the drawing. In this case also, the electric current does not flow along a spiral path in the electrode pin portions 5a and 5d as was the case with the previous embodiments, and the electric resistance and inductance can be reduced.

Because the tapered hole section 2a is not required to be formed, the forming and assembling processes are simplified. For instance, during a time period in which products of a same model are required to be tested, a same relay board may be kept integrally attached to the upper surface of the upper insulating plate 1 with the upper electrode pin portion 5b kept constantly in contact with a terminal on the relay board. Because only the lower electrode pin portion 5a is required to be accessed each of the products to be tested, the electroconductive contact unit 3 in the form of a coil spring is allowed to

undergo a cyclic compression without risking the dislodging of the contact unit from the assembly. This contributes to the reduction in cost.

The gold plate layer 8a was formed prior to the coiling process in the embodiment illustrated in Figure 2, but the coil wire 3a may be subjected to  
5 the coiling process without any gold plating process so that only a single gold plate layer (corresponding to the second gold plate layer 8b) is formed over the surface of the assembly.

For instance, as shown in Figure 7(a), the coil wire 3a may be subjected to a coiling process so as to form a coil spring portion 4 and  
10 electrode pin portions 5a and 5b which consist of closely wound sections as was the case in the previous embodiments. A gold plating process is applied to the assembly in the state illustrated in Figure 7(a), and a gold plate layer 8b is formed over the entire outer circumferential surface of each closely wound section. In this case also, the plating material is not limited to gold but may  
15 consist of Ni or Cu.

In either case, the material for the coil wire 3a may be selected freely without regard to the electric conductivity, and may consist of inexpensive spring material.

## CLAIMS

1. An electroconductive contact unit assembly comprising a  
electroconductive contact unit in the form of a coil spring for resiliently  
5 contacting an object to be contacted, the contact unit being coaxially received  
in a through hole formed in an insulating support member, characterized by  
that:  
  
the through hole is shaped so as to have a reduced diameter portion at  
least at one axial end thereof;  
10 the contact unit in the form of a coil spring comprising a coil spring  
portion received in an intermediate part of the through hole and a pair of  
electrode pin portions, which are each closely wound at corresponding ends of  
the coil spring portion, and at least one of which is tapered or stepped in shape  
so as to be prevented from coming off by the reduced diameter portion;  
15 the contact unit being surface processed by highly electroconductive  
material.  
  
2. An electroconductive contact unit assembly according to claim 1,  
wherein the reduced diameter portion comprises a tapered hole section  
20 provided at each axial end of the through hole, and the pair of electrode pin  
portions are tapered in shape and closely wound so as to be prevented from  
coming off by the tapered hole sections of the through hole.  
  
3. An electroconductive contact unit assembly according to claim 1,  
25 wherein the reduced diameter portion has a smaller inner diameter than the

outer diameter of the coil spring portion, and is provided at each axial end of the through hole, and the other of the pair of electrode pin portions has a cylindrical shape which has a smaller diameter than the reduced diameter portion.

5

4. An electroconductive contact unit assembly according to any one of claims 1 to 3, wherein the coil spring portion is wound at a uniform pitch.

5. An electroconductive contact unit assembly according to any one of claims 1 to 4, wherein the electrode pin portions are each closely wound with a pre-stress.

6. An electroconductive contact unit according to any one of claims 1 to 5, wherein the surface processing is conducted after the coil spring portion and electrode pin portions are formed out of a wire member.

7. An electroconductive contact unit according to any one of claims 1 to 5, wherein the surface processing is conducted both before and after the coil spring portion and electrode pin portions are formed out of a wire member.

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## ABSTRACT

A low electric resistance is accomplished because there are no parts connecting different components as opposed to the arrangement using an electroconductive needle member and an electroconductive coil spring, and a low electric inductance can be accomplished because the coil spring is closely wound and surface processed with highly electroconductive material, thereby providing a straight electric path along the axial direction of the closely wound portion of the coil spring. Because the coil spring portion has a uniform pitch, and the contact unit consists of closely wound portions and the uniform pitch portion, it can be formed with a simple coiling process, and the manufacturing cost can be minimized.

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## (57) Abstract

A conductive contact is provided which can be of lower resistance than those having a combination of a conductive needle and a conductive coiled spring because it includes no joint between different components. The conductive contact takes the shape of a coiled spring that is coated with highly conductive material and wound so that adjacent coils are in close contact with one another. Therefore, a linear electrical path is formed in parallel to the axis of the coiled spring, resulting in low impedance. The coiled spring is of single pitch winding and it can be formed simply of regular-pitch part and contact-coil part, thus reducing manufacturing costs.

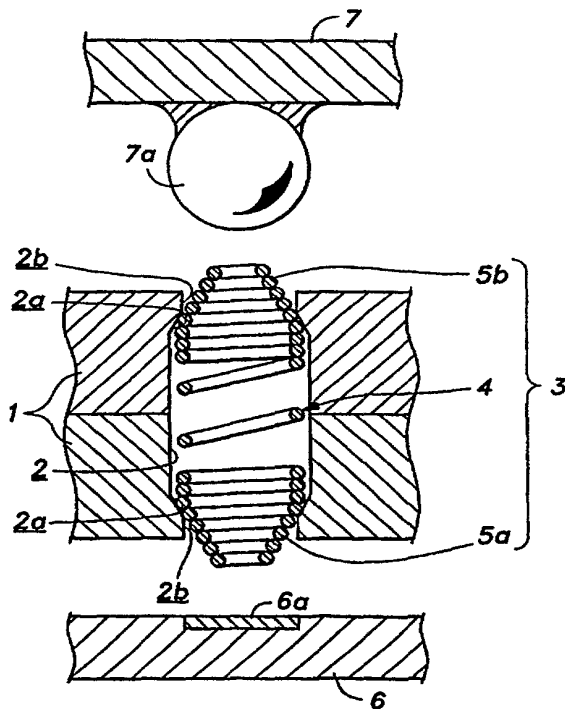


Fig. 1

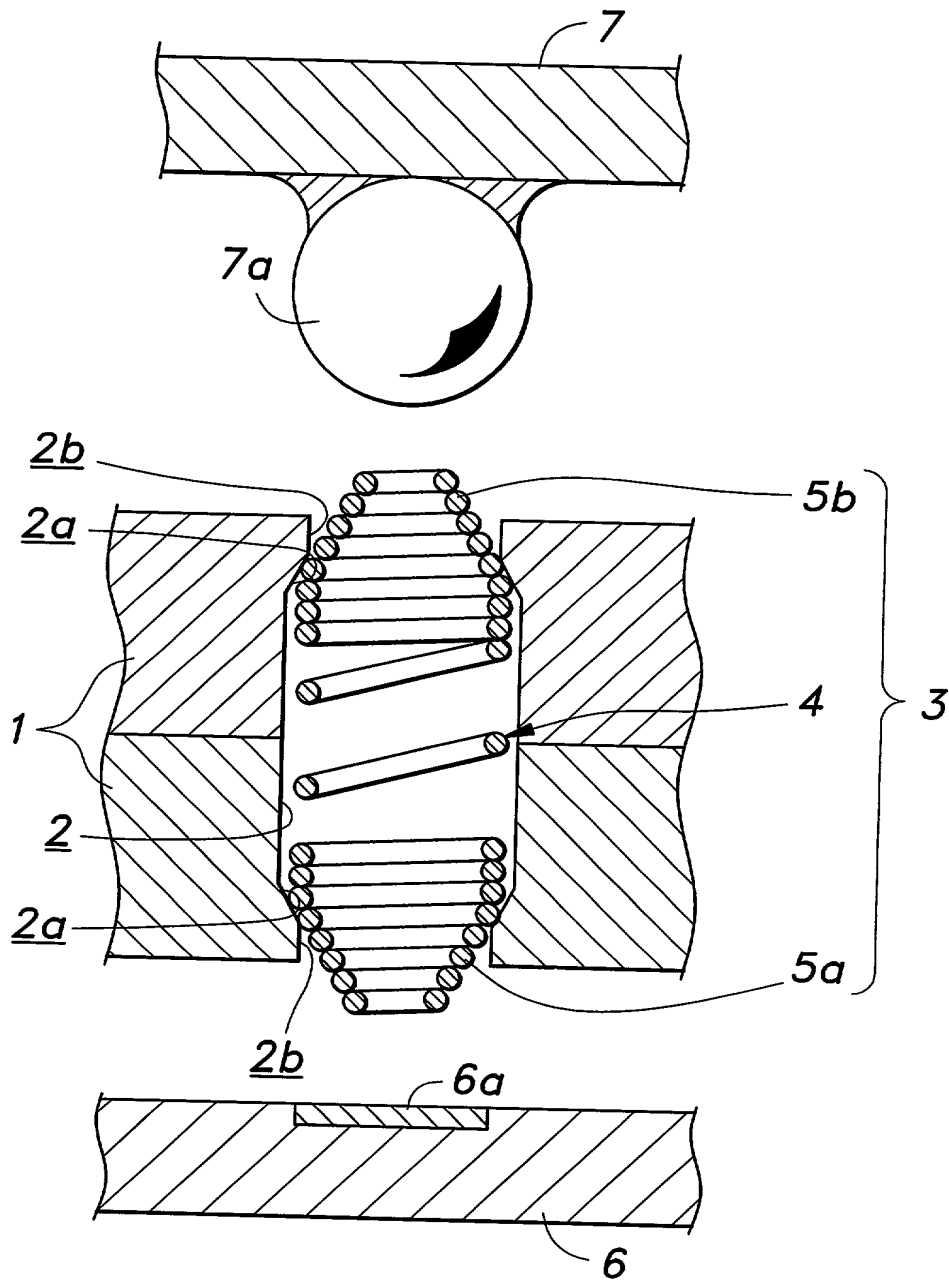


Fig. 2(a)

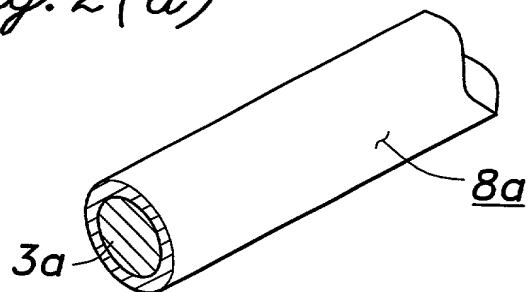


Fig. 2(b)

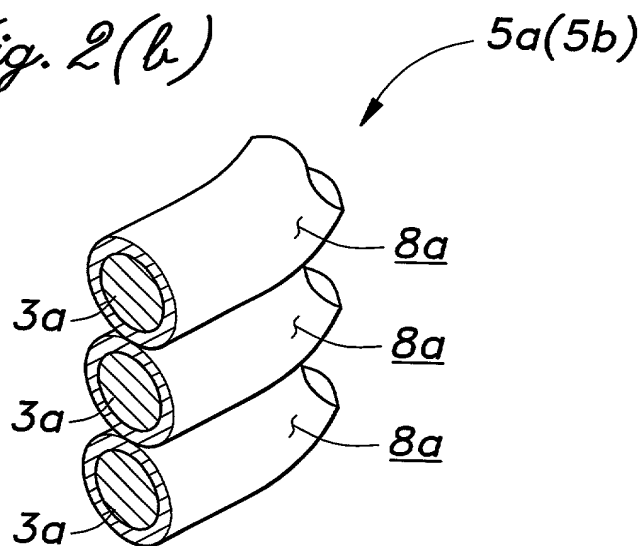


Fig. 2(c)

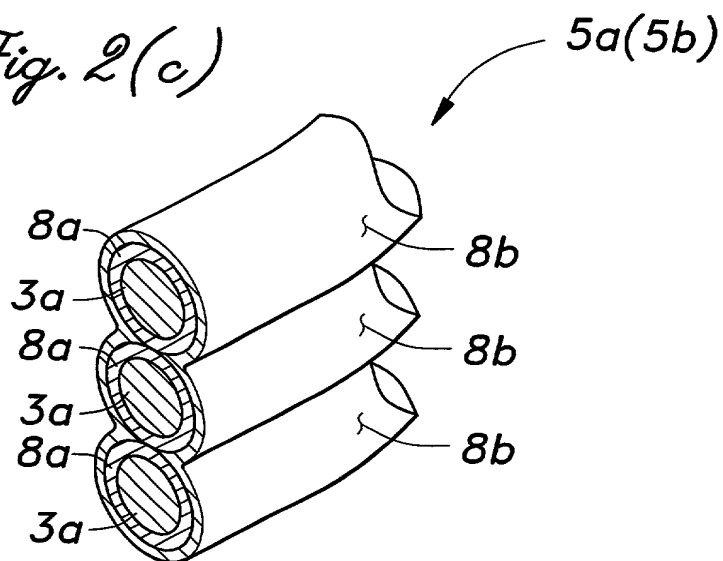




Fig. 3

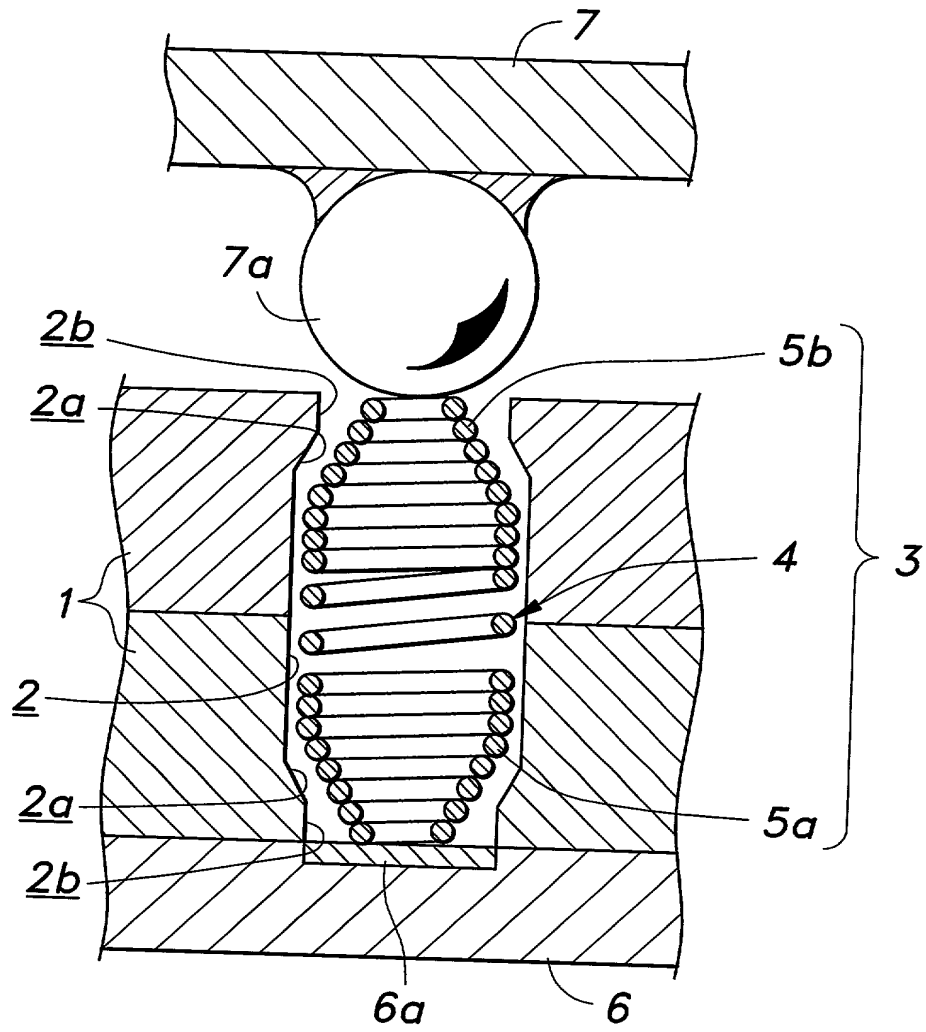


Fig. 4

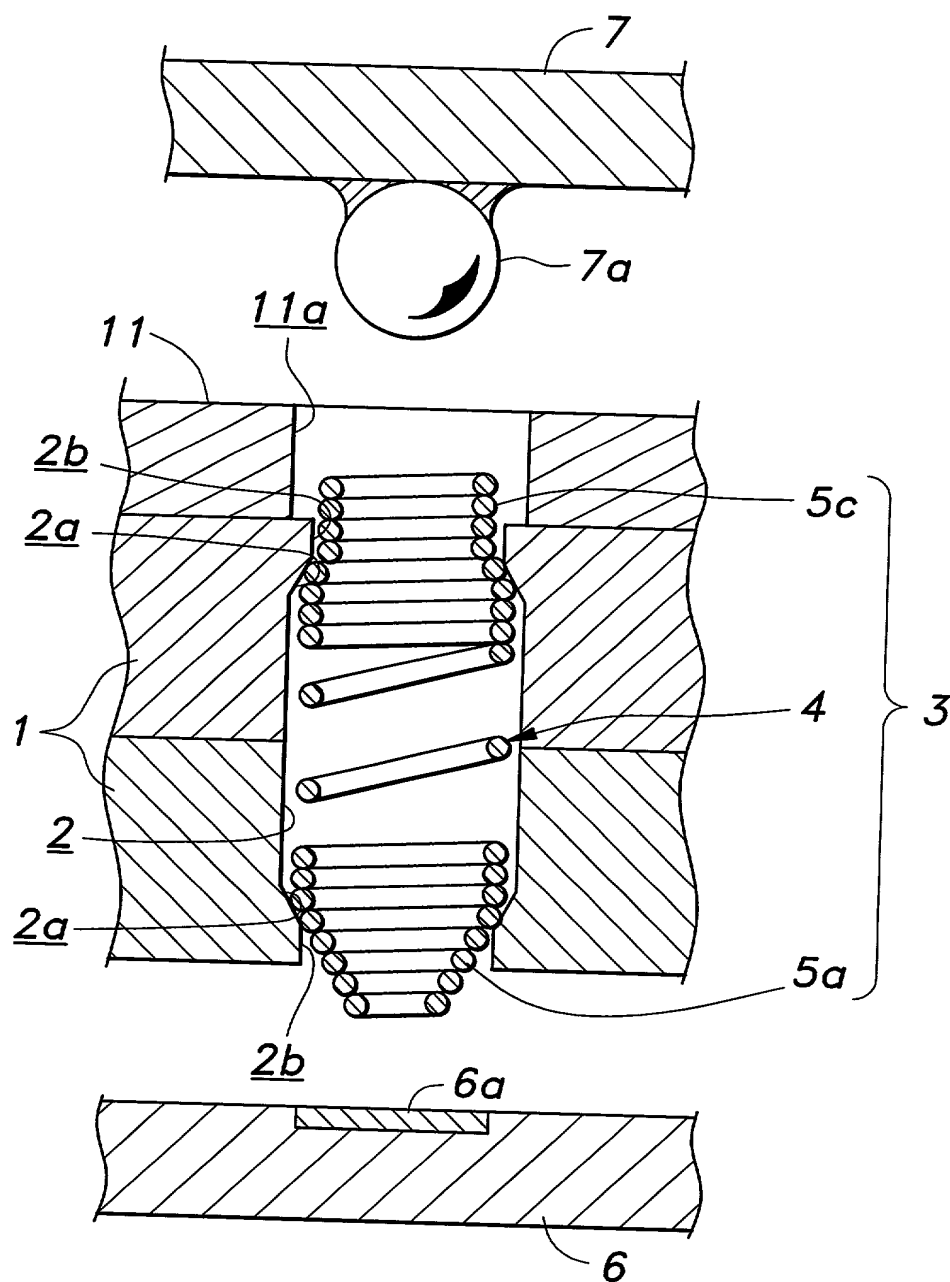


Fig. 5

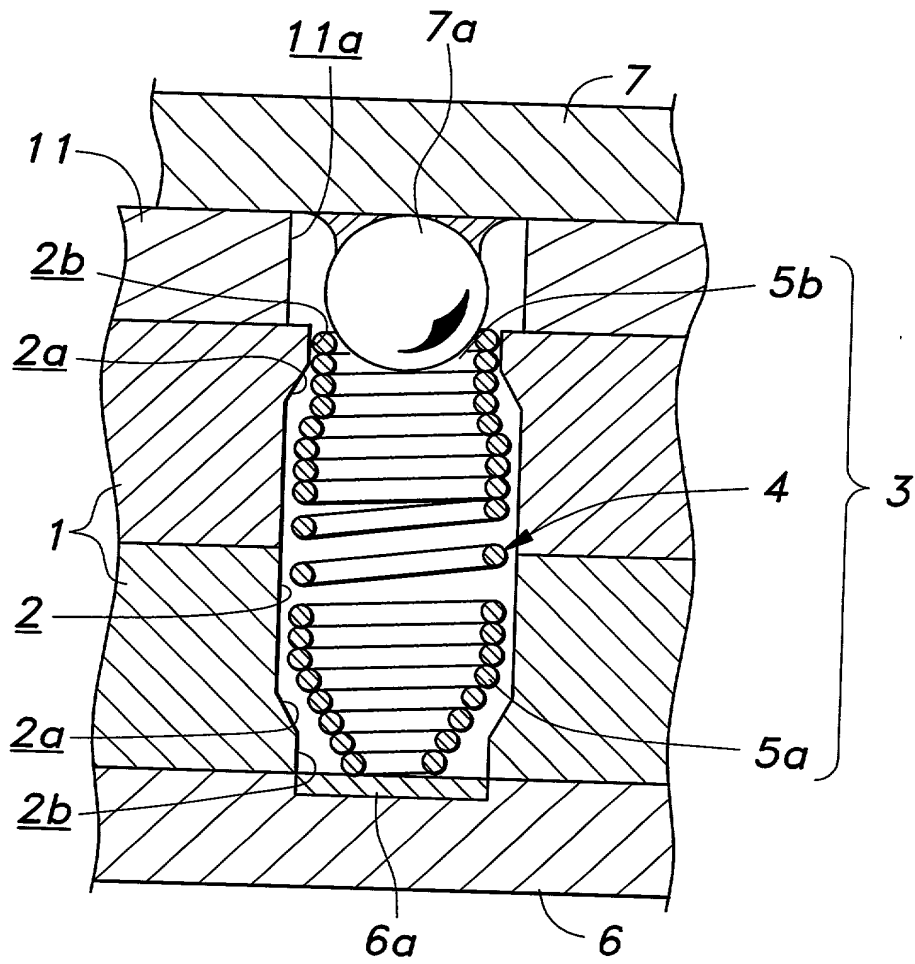
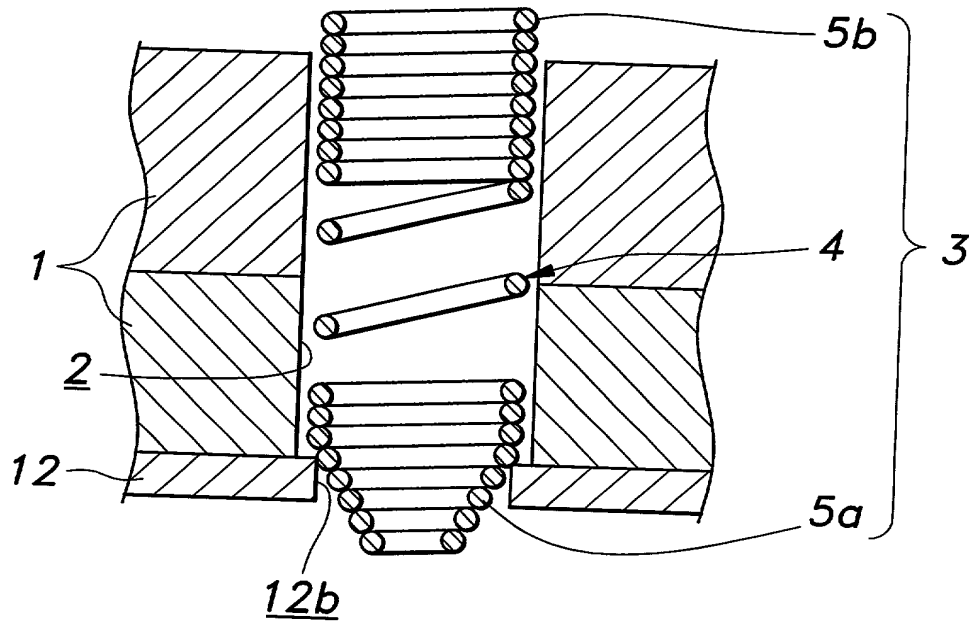
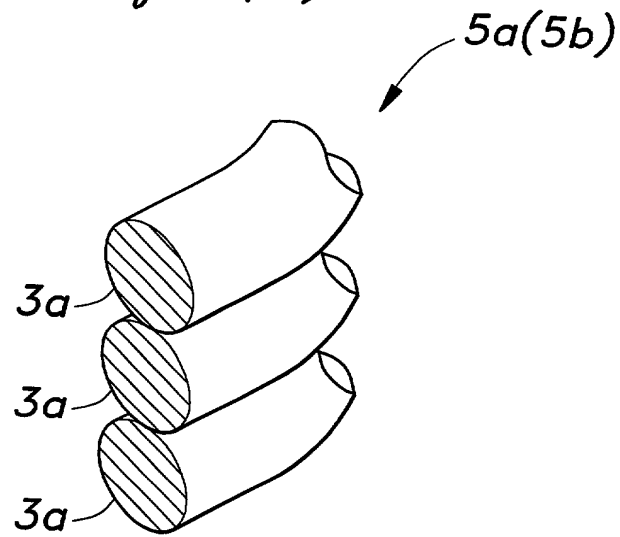


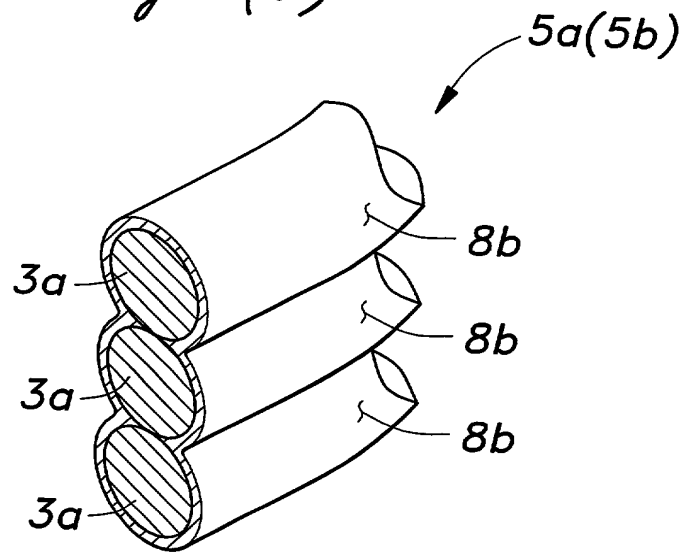
Fig. 6



*Fig. 7(a)*



*Fig. 7(b)*



## DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am an original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled " ELECTROCONDUCTIVE CONTACT UNIT ASSEMBLY ", the specification of which is attached hereto unless the following box is checked:

☒ was filed on July 9, 1999 as PCT International Application No. PCT/JP99/03714 and was amended on December 17, 1999 and/or was filed on January 10, 2001 as United States Application No. 09/743,536 and was amended on January 10, 2001.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 USC 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed.

### Prior Foreign Application (s)

Number	Country	Filing date	Priority claims
Patent 10-195808	Japan	July10, 1998	Yes

I hereby claim the benefit under 35 USC 119(e) of any United States provisional application(s) listed below.

Application No. \_\_\_\_\_ Filing date \_\_\_\_\_ Status \_\_\_\_\_

I hereby claim the benefit under 35 USC 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 USC 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or \_\_\_\_\_ Parent Filing date \_\_\_\_\_ Parent Patent Number \_\_\_\_\_  
PCT Parent No. \_\_\_\_\_ (if applicable) \_\_\_\_\_

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 USC 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00  
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